Supplemental Material

Trait-environment relationships could alter the spatial and temporal characteristics of aquatic insect subsidies at the macrospatial scale

Table S1. Number of sites exceeding a threshold indicating the proportion of flying individuals with trait data for each hydrologic region. For this analysis we chose > 0.5 to maintain a minimum sample size ($n \geq 3$) for all hydrologic regions.

	Threshold for Inclusion in Traits Analysis								
Hydrological Region	**>0.1**	**>0.2**	**>0.3**	**>0.4**	**>0.5**	**>0.6**	**>0.7**	**>0.8**	**>0.9**
01	84	64	52	39	32	21	11	4	0
02	103	93	77	56	42	19	5	1	0
03N	53	38	25	10	7	5	3	0	0
03S	17	8	5	4	3	2	1	0	0
03W	51	43	29	18	13	6	3	2	0
04	75	54	44	36	27	19	8	3	0
05	102	79	63	42	30	16	8	3	0
06	30	23	17	12	6	1	0	0	0
07	124	95	77	51	31	22	13	9	2
08	79	59	44	30	22	13	8	2	2
09	23	18	12	9	6	3	1	0	0
10L	93	78	63	50	31	26	20	14	7
10U	180	161	143	122	98	79	51	28	12
11	111	91	71	50	37	22	12	4	0
12	33	31	29	21	17	10	7	4	2
13	21	20	17	16	14	11	10	4	2
14	53	50	47	38	32	25	19	12	4
15	38	35	31	25	21	17	11	7	1
16	44	37	34	33	22	16	12	5	0
17	117	103	89	74	61	42	26	14	3
18	39	35	32	29	22	15	9	5	3
Total	1470	1215	1001	765	574	390	238	121	38

Table S2. Top) Variable importance rankings for duration and extent traits (bottom) using sites meeting different threshold values for community traits data. At the 50% threshold (used in the main text) sites with > 50% of their flying taxa have traits data are included in the analysis. Note, many thresholds have similar important variables but the percent variation explained (PVE) decreases with more conservative threshold values. Predictor variables are: AREA = Catchment area, ELEV = Elevation, SLOPE = Channel Slope, FINES = Percent Fine Substrate, EMBED = Percent Embeddedness, AGRI = Percent Agricultural Land Cover, URBAN = Percent Urban Land Cover, PRECIP = Mean Annual Precipitation, TEMP_MA = Mean Annual Temperature, TEMP_CoV = Mean Annual Temperature Coefficient of Variation, PRECIP_CoV = Mean Annual Precipitation Coefficient of Variation, HYDROCLASS = hydrological class. Trait abbreviations are: FDH = Female Dispersal (High), BSL = Body Size (Large), LSL = Life Span (Long), FSS= Flight Strength (Strong); ESP = Emergence Synchrony Poor; DSF = Development Speed (Fast) and VOM = Voltinism (Multi); Trait definitions are provided in Table 1

	DSF				**VOM**				**ESP**			
Predictor	**Threshold**				**Threshold**				**Threshold**			
Variable	**>50%**	**>60%**	**>70%**	**>80%**	**>50%**	**>60%**	**>70%**	**>80%**	**>50%**	**>60%**	**>70%**	**>80%**
AGRI		2	1	3								
FINES			5	1								
SLOPE							6	5				
TEMP_MA	6	3	3	4				3	5	5	4	1
TEMP_CoV	1	1	2		1	2	2	2	2	1	2	5
EMBED			6									6
ELEV	2	4	4	2								4
HYDROCLASS	5	6			4	3	3		6			
PRECIP_CoV				5	5	4	5	6		6	6	
PRECIP	4			6	6	6	4	4	4	4	3	3
REGION	3				2	1	1	1	3	2	1	2
URBAN		5										
AREA					3	5			1	3	5	
PVE	**0.26**	**0.2**	**0.17**	**0.06**	**0.3**	**0.3**	**0.3**	**0.16**	**0.21**	**0.26**	**0.23**	**0.12**

	FSS				**LSL**				**FDH**				**BSL**			
Predictor	Threshold				Threshold				Threshold				Threshold			
Variable	**>50%**	**>60%**	**>70%**	**>80%**	**>50%**	**>60%**	**>70%**	**>80%**	**>50%**	**>60%**	**>70%**	**>80%**	**>50%**	**>60%**	**>70%**	**>80%**
AGRI					6	3	2			2	2		5			
FINES			6		4				2	3	1					
SLOPE		1	2								5			5	6	
TEMP_MA			4			6	4								4	3
TEMP_CoV	3	2	5		1	2	1		4		4		1	1	2	5
EMBED	2	6			5	5	6		6							6

ELEV																
HYDROCLASS	5				2	1	3		3	5			4	4	5	4
PRECIP_CoV													6			
PRECIP		3					5						3	3	3	2
REGION	4								5	6			2	2	1	1
URBAN	6	5	3		3	4				4	6					
AREA	1	4	1						1	1	3			6		
PVE	**0.04**	**0.01**	**0.01**	**-0.04**	**0.13**	**0.05**	**0.02**	**-0.06**	**0.16**	**0.13**	**0.08**	**0**	**0.26**	**0.25**	**0.25**	**0.05**

Table S3: Prior distributions for Bayesian regression models. Mean and standard deviation for proportional data are logit transformed. Trait abbreviations are: FDH = Female Dispersal (High), BSL = Body Size (Large), LSL = Life Span (Long), FSS= Flight Strength (Strong); ESP = Emergence Synchrony Poor; DSF = Development Speed (Fast) and VOM = Voltinism (Multi); Trait definitions are provided in Table 1

Subsidy Characteristic	Trait	Prior Information
Supply	Flying	N(0.85, -1.45)
Extent	SS25	N(21.5, 18)
	BSL	N(-2.44, -2.59)
	LSL	N(-1.90, -1.82)
	FDH	N(0.28, -1.15)
	FSS	N(-1.66, -1.39)
Duration	DSF	N(1.52, -1.59)
	VOM	N(-0.58, -1.39)
	ESP	N(-1.45, -1.73)

Table S4: Descriptive statistics and model performance metrics. Trait abbreviations are: SS25 = community-weighted 25% stream signature, BSL = maximal body length > 9mm, LSL = adult life span > 1 week; FDH = high female dispersal, FSS = Strong flying strength, DFS = Fast development, VOM = Multivoltinism, ESP = Poorly Synchronized Emergence. Trait definitions are given in Table 1. OBO R^2 = Out of Bag R^2, NSE = Nash–Sutcliffe efficiency, RSR = ratio of the root mean square error to the standard deviation of observed data (RSR) and MAE = mean absolute error.

Subsidy Characteristic	Trait	National Mean (±SD)	OBO R^2	NSE	RSR	MAE
Supply	Flying	0.65 (±0.26)	0.31	0.32	0.83	0.17
Extent	SS25	31.09 (±12.59)	0.18	0.22	0.88	8.79
	BSL	0.32 (±0.26)	0.26	0.23	0.87	0.17
	LSL	0.29 (±0.26)	0.10	0.12	0.93	0.2
	FDH	0.16 (±0.20)	0.19	-0.01	1	0.15
	FSS	0.20 (±0.24)	0.03	0.06	0.96	0.18
Duration	DSF	0.47 (±0.31)	0.26	0.24	0.87	0.23
	VOM	0.48 (±0.31)	0.28	0.26	0.86	0.23
	ESP	0.37 (±0.28)	0.18	0.22	0.88	0.21

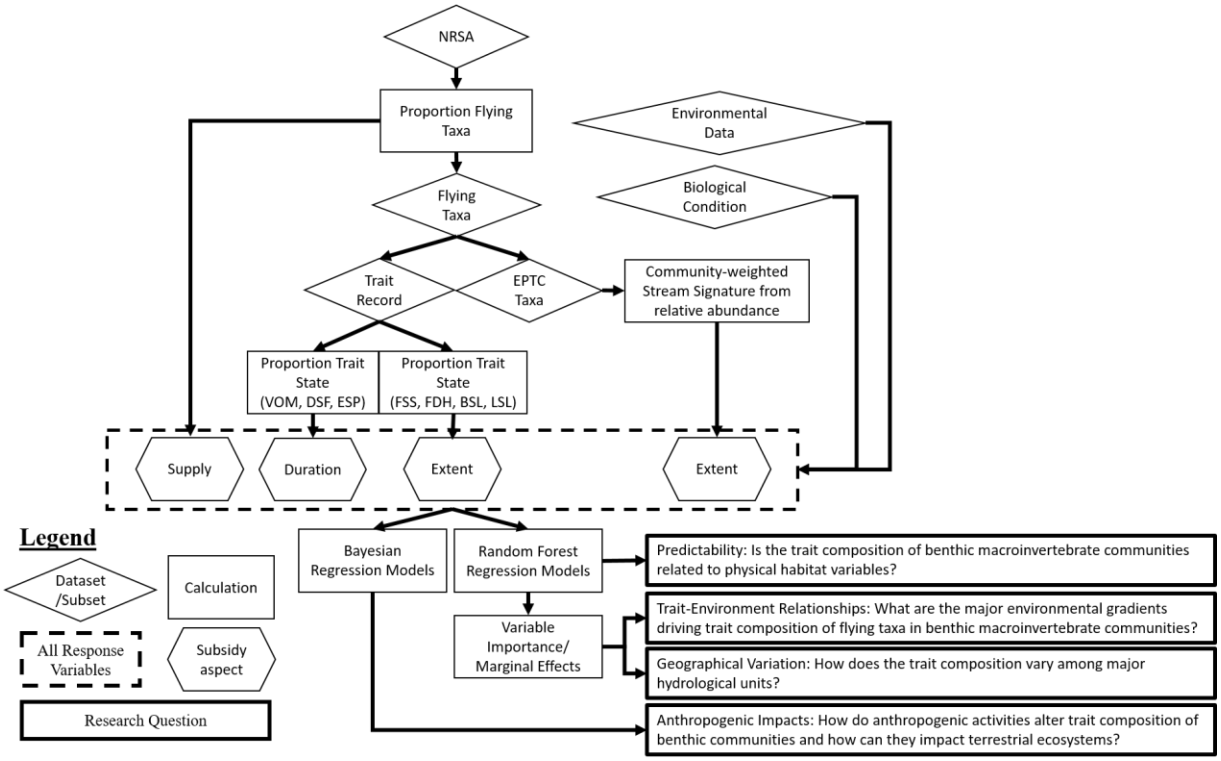

Figure S1. Schematic of investigation with path to research questions in the main text. NRAS = composite benthic macroinvertebrate samples collected by the national rivers and streams assessment; Flying taxa = Diptera, Ephemeroptera, Plecoptera, Odonata and Trichoptera; EPTC taxa = Ephemeroptera, Plecoptera, Trichoptera and Chironomidae [Diptera]; Traits Record = flying taxa with matching record in traits database. Trait abbreviations are: Trait abbreviations are: FDH = Female Dispersal (High), BSL = Body Size (Large), LSL = Life Span (Long), FSS= Flight Strength (Strong); ESP = Emergence Synchrony Poor; DSF = Development Speed (Fast) and VOM = Voltinism (Multi); Trait definitions are provided in Table 1

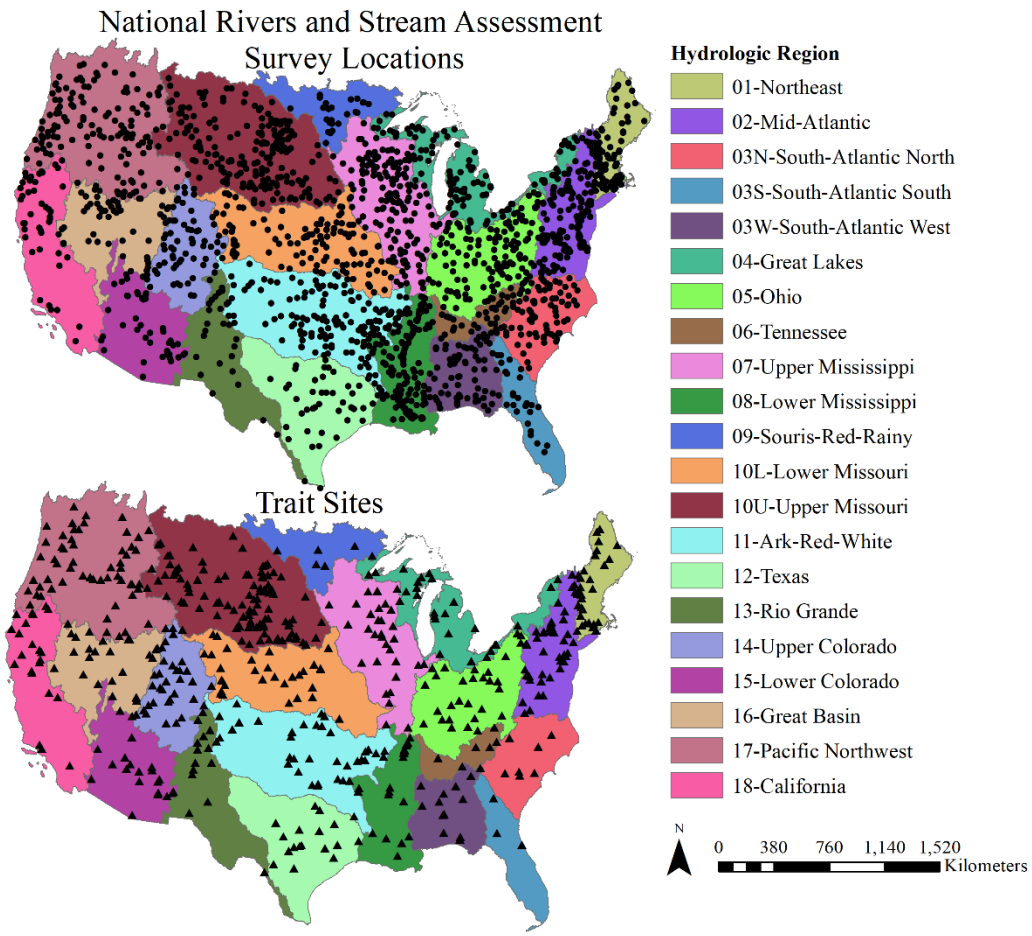

Figure S2. Top: Major Hydrologic Regions of the United States with survey locations used by National Rivers and Stream Assessment program (Points, n = 1,857). Bottom: Survey locations where > 50% of the EPTDO genera have suitable information about traits (Triangles, n = 578).

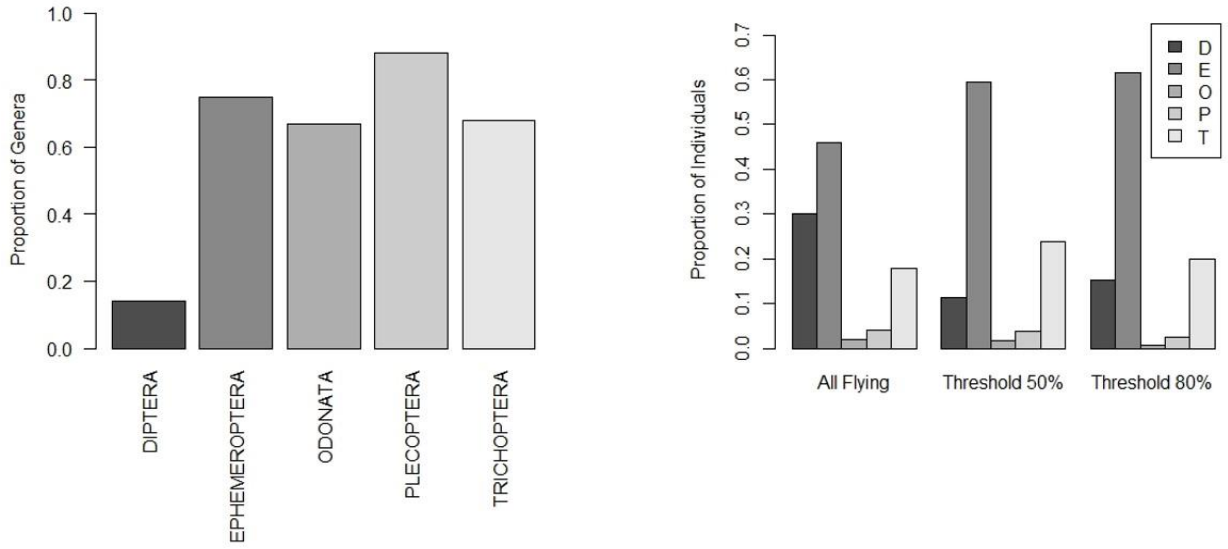

Figure S3. Left: The proportion of flying genera with trait data collected during the NRSA survey. Note trait data were available for 14% of the Diptera, thus these taxa may be underrepresented in the traits analysis. Right: The composition of flying taxonomic Orders at all NRSA survey locations (All flying) and at sites included in the 50% threshold (i.e. trait data available for >50% of the flying taxa community) and 80% threshold. Relative to all NRSA survey locations, the sites included in the traits analysis have lower frequencies of Diptera and higher frequencies of Ephemeroptera.

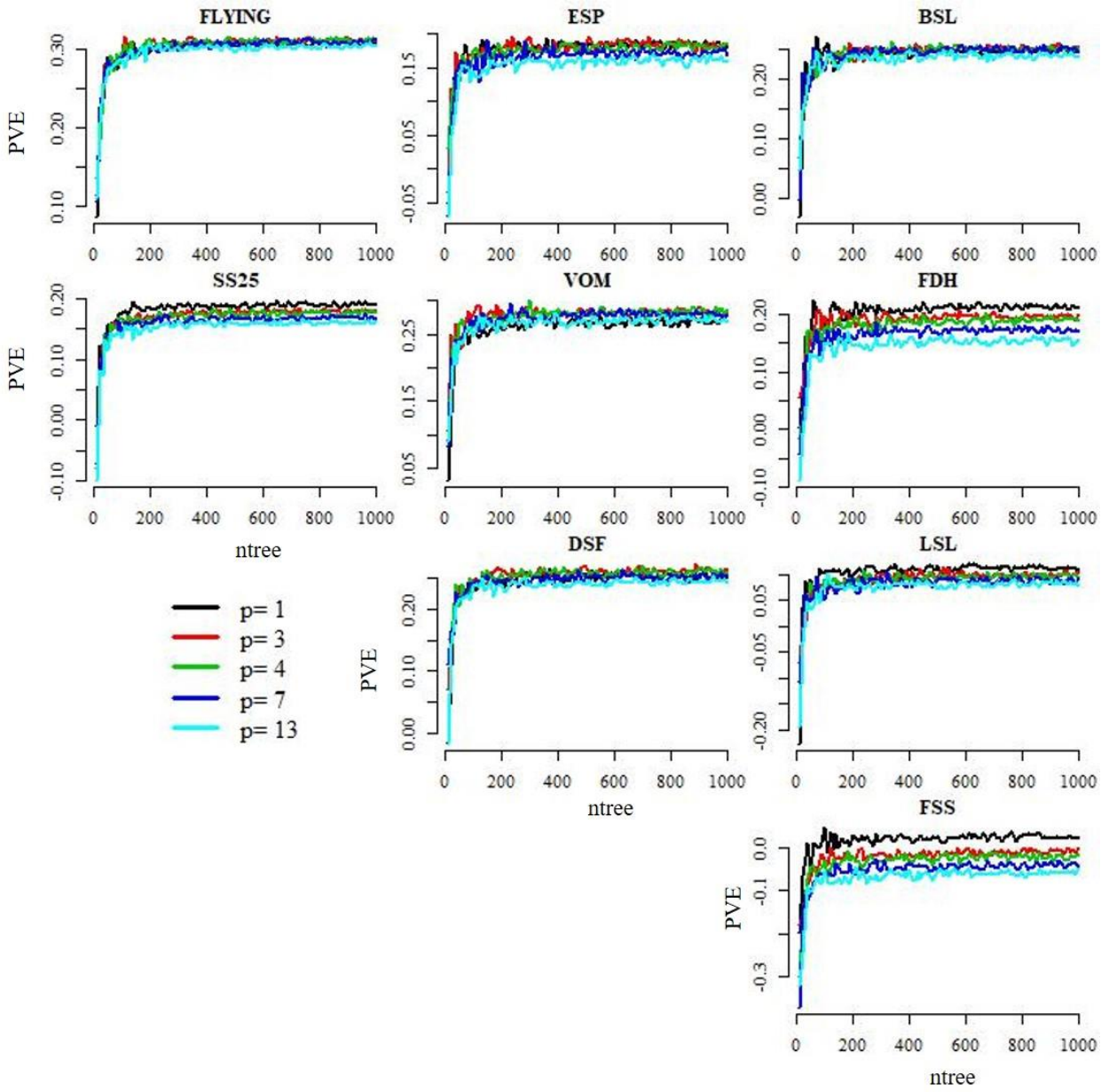

Figure S4. Convergence of the proportion of variation explained (PVE) for different values of mtry (p) with increasing the number of trees (ntree). We selected 1, $2\sqrt{p}$, $0.2p$, $p/3$ and p as candidate mtry values. Consistent with other studies (Fox et al. 2017), we found the optimal value for mtry offered little improvement (i.e. <5% change in PVE) over the default ($p/3 = 4$) for all models except FSS. This model explained little variation in the proportion of individuals with strong flight strength and mtry=1 is possibly indicating stochastic outcome.

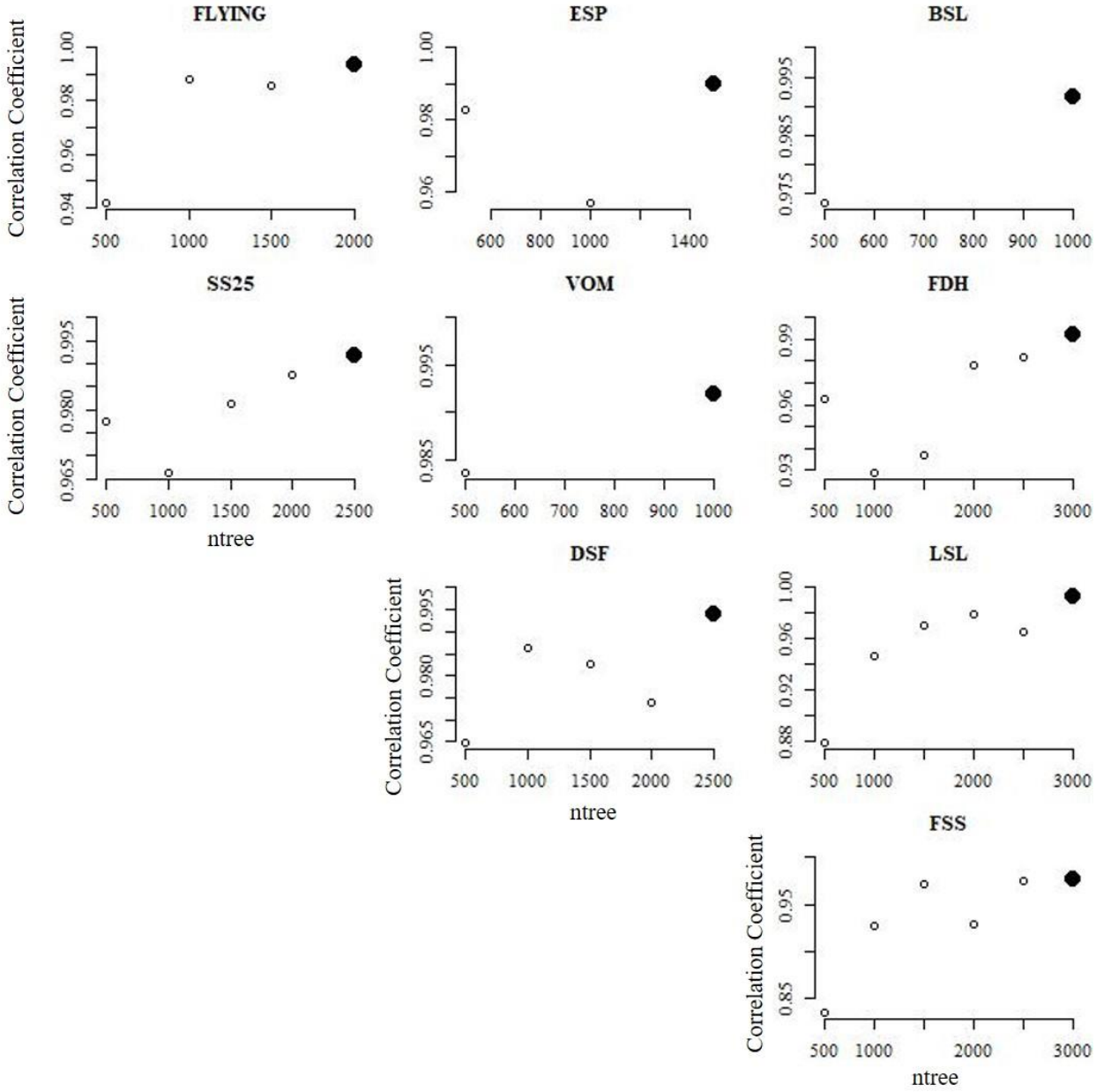

Figure S5. Correlation coefficients between the variable importance values from two independent random forest models. We tested several values for ntree (500, 1000, 1500, 2000, 2500 and 3000) and found the consistency of results (i.e. correlation coefficient) increased with the number of trees. At ntree =3000 the agreement in the variable importance values >0.98 for all models.

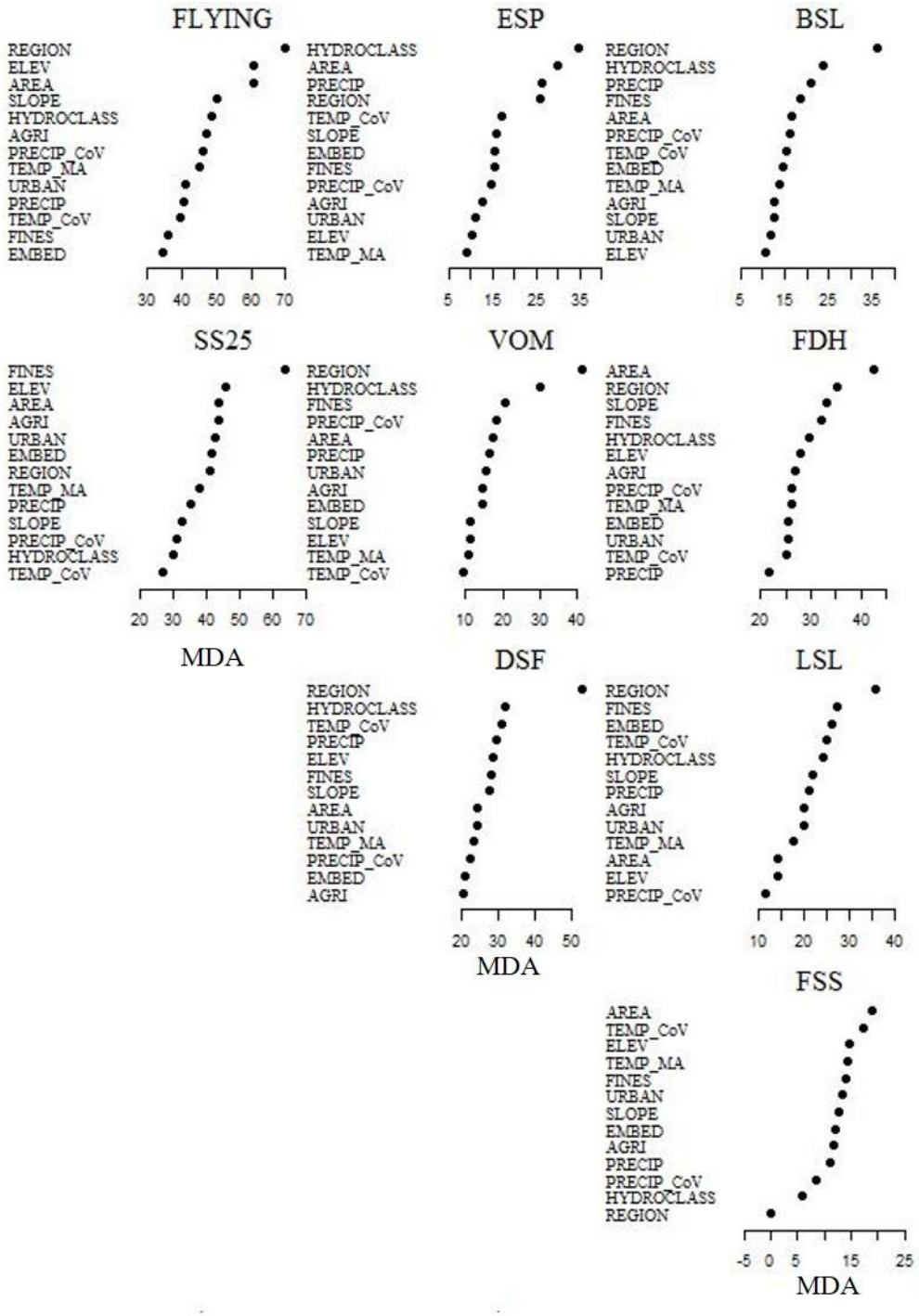

Figure S6. Variable importance plots (MDA = mean decrease accuracy). Predictor variables are: AREA = Catchment area, ELEV = Elevation, SLOPE = Channel Slope, FINES = Percent Fine Substrate, EMBED = Percent Embeddedness, AGRI = Percent Agricultural Land Cover, URBAN = Percent Urban Land Cover, PRECIP = Mean Annual Precipitation, TEMP_MA = Mean Annual Temperature, TEMP_CoV = Mean Annual Temperature Coefficient of Variation, PRECIP_CoV = Mean Annual Precipitation Coefficient of Variation, HYDROCLASS = hydrological class. Trait abbreviations are: FDH = Female Dispersal (High), BSL = Body Size

(Large), LSL = Life Span (Long), FSS= Flight Strength (Strong); ESP = Emergence Synchrony Poor; DSF = Development Speed (Fast) and VOM = Voltinism (Multi); Trait definitions are provided in Table 1